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Research Artikel

ANALYZING THE NEEDS OF TEACHING AND LEARNING CONTENT LOW CARBON EDUCATION AT JUNIOR HIGH SCHOOL IN INDONESIA

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Abstract

This study aims to identify the needs in the development of teaching materials on low carbon education, which is still rarely delivered at the VII grade secondary school level. This research uses the Mix Method. Quantitative data collection with a total of 100 respondents located in Bogor regency in the 2024/2025 academic year using assessment questions on the level of knowledge, low carbon competencies, and environmental care attitude questionnaire. Meanwhile, qualitative data were generated from observations of climate resilience based on the geographical location of the education unit. The results of this study show that students still need improvement in knowledge, low carbon competency, and environmental care attitude. The climate resilience analysis shows that the school conditions have the potential to implement learning that raises environmental issues to be used as topics in learning, and the use of social media. Therefore, the need for the development of teaching materials includes learning that contains videos or images, case studies with local issues, accompanied by group assignments that integrate social media as a medium for campaigns to protect the environment, so that it accommodates learning that forms an attitude of environmental care.

Keywords*: Competence; climate resilience; environmental stance; knowledge; low carbon.*

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INTRODUCTION

Low carbon knowledge and competence from the results of this study were found to be still low that which needs to be improved to support students as part of the school community to be able to play a role in protecting the environment through environmental conservation starting from school. In Bogor District, environmental education has been strongly promoted through the environmental culture care movement program through Adiwiyata School. The development of the Adiwiyata program in Bogor Regency is very positive, marked by a number of verified schools reaching the Adiwiyata Mandiri level (SETDA, 2024). Knowledge and competencies to support the formation of the character of environmental care attitudes need to be taught through teaching materials in teaching and learning activities (Santika et al., 2023). Asrial et al., (2021) revealed that relevant teaching materials with the selection of appropriate learning models and methods can shape and improve students' environmental care attitudes.

Curriculum analysis is the first step in developing, preparing, and designing the learning objectives that students need (Latif et al., 2019). In curriculum analysis, there is also an analysis of the learning content needed by students based on the independent curriculum is seen from the phase D learning outcomes for Junior High School the compiled into learning objectives and then elaborated into a flow of learning objectives. The independent curriculum gives educators the freedom to develop the content to be taught according to be specific needs of the region (Tunas & Pangkey, 2024)

The Kurikulum Merdeka also includes climate change education as one of the mitigation and adaptation efforts to climate change currently faced because education is considered to have a huge influence to encourage real change through 'changing perspectives, mindsets to behavior to protect the environment through the insertion of concepts, materials to form knowledge and competencies in learning designs so that students can educate themselves to care for their environment (Mahfud & Setya Budi, 2025)

Climate change education includes a discussion of the causes, impacts, and ways of mitigation and adaptation. The cause of climate change is Greenhouse Gases (GHG) produced by human activities, ranging from energy use through burning coal used by humans, CO_2 gas released by humans, meat consumption, accumulation of organic and inorganic waste that has the potential to emit methane gas and even carbon dioxide from burning inorganic waste that is not managed properly (PBB Indonesia, 2022)

Knowledge and competencies for climate change mitigation and adaptation can also be delivered specifically through low carbon education. Low carbon is a very influential concept for efforts to reduce carbon emissions (Yuan et al., 2011). Low carbon education in schools is measured by several indicators in the energy sectors, transportation, procurement of efficient equipment (environmentally friendly school infrastructure), green areas, and waste management (from production to waste management with Reduce, Reuse, Recycle) (Marques-Valderrama et al., 2023). In this study, the waste management indicator will be the focus in the application of low carbon education as the instrument used contains questions about knowledge of types of waste, waste issues, impacts, and how to deal with them.

This research aims to make a practical contribution by analyzing the needs for developing low carbon education teaching materials based on school geographical conditions and student characteristics, to propose an innovative, contextual framework and relevance. Promote low carbon practices in secondary education to reduce the gap between

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the global environment and local implementation of environmental education.

METHOD

This research applies the Mix Method with a convergent parallel design, quantitative data collection using low carbon knowledge and competency assessment instruments, and a survey of students' environmental care attitudes, which are analyzed using descriptive analysis. The subjects in this study were 100 junior high school students in the Bogor district in the 2024/2025 school year.

Simultaneously, qualitative data were collected through observations of the climate resilience of the school's geographical conditions, adapted from the Ministry of Education's climate change book. After the quantitative and qualitative analysis was conducted, the data were explored for similarities and differences in their findings. Furthermore, data triangulation was carried out between knowledge, competencies, environmental care attitudes, and the results of climate resilience observations according to the geographical conditions of the school.

Quantitative data analysis technique, the percentage of individual learner achievement in learner knowledge and competence is calculated using the formula. (Evriana et al., 2016):

$$Percentage = \frac{Total\ Score}{Maximum\ Score}\ X\ 100\ \%$$

The data analysis technique for students' environmental care attitude is to calculate the percentage using a Likert scale containing 5 alternative answers. Score 5 for the highest score and score 1 for the lowest score (Apriyani et al., 2021) and analyzed the data by calculating the frequency distribution with the categories very low, low, medium, high, and very high (Adri et al., 2024). The correlation between knowledge and low carbon competence of students was analyzed using the Pearson correlation test using SPSS 26 and found to be positively correlated with a sig value. (2-tailed) 0.214<0.05 (Jabnabillah & Margina, 2022).

The low carbon education test instrument in this study has passed the validation stage, as 2 instrument experts obtained a reliability coefficient of 0.707, which was tested by the Cronbach alpha formula (Khumaedi, 2012). These gains are included in the high reliability criteria (Guilford, 1956). The validity test of the research instrument has also been carried out on 43 students in class IX before being implemented on the research subjects, and the question items were declared valid with a 2-tailed significance value <0.05.

RESULTS AND DISCUSSION

The needs analysis for the development of teaching materials has been carried out on 100 junior high school students in Bogor district in the 2024/2025 academic year. The instruments used include low carbon knowledge and competency questions and survey instruments for students' environmental care attitudes. Then, an analysis of climate resilience based on geographical location was also carried out using instruments adapted from the Ministry of Education and Culture's climate change book.

Based on the data analysis that has been carried out, it is found that the knowledge and competence of students need to be improved again, here is the average achievement of students on knowledge and competence regarding low carbon in Figure 1.

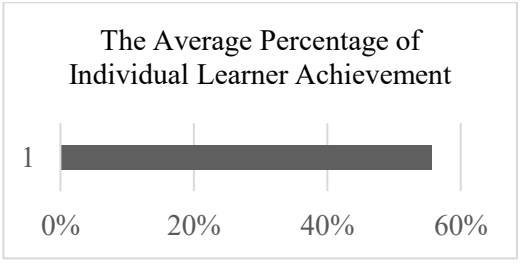

Figure 1. The Average Percentage of Individual Learner Achievement

Based on the data that has been obtained, it is only 57% of students reach the minimum individual absorption (Daya Serap Individu) in the knowledge aspect, and the carbon competence of students is still low. The individual absorption of students has been said to be complete if it has reached equal to or more than 60% and competence regarding low carbon education. Evriana et al., (2016) also stated that the level of comleteness of learning achievement or individual absoption is said to be complete if it has passed equal to more that 60%.

Absorption is the ability of students to take or absorb what they have learned (Haryani et al., 2021). Learning that is systematic, has clear objectives and is in accordance with the needs of students is needed to increase students' knowledge and competence. Teachers play a very important role in designing meaningful learning. (Ummah et al., 2024). Low carbon education teaching materials can be designed according to the geographical conditions of students, so that learning will feel close, contextual, and meaningful to students. (Handoyo & Sukamto, 2019).

The achievement of low carbon knowledge of learners was 1% very low 32% low, 27% medium, 28% high and only 12% fell into the very high category. Below in Figure 2 is the diagram for learners' low carbon knowledge.

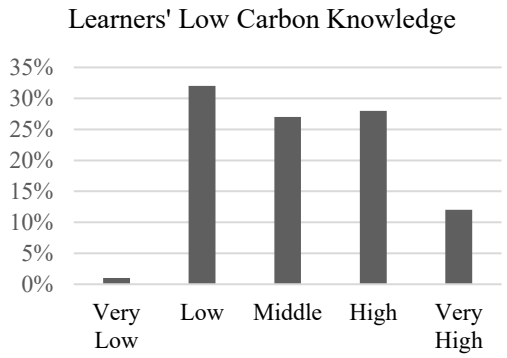

Figure 2. Learners' Low Carbon Knowledge

The achievement of the low carbon competence of students was found to be 3% in the very low category, 39% low category, 30% medium category, 18% high and only 10% in the very high category. Below is a diagram of students' low carbon competence.

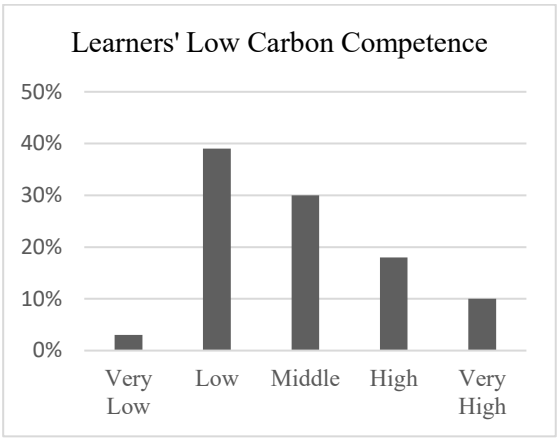

Figure 3. Learners' Low Carbon Competence

From the data analysis of the correlation between knowledge and low carbon competence, it is found that knowledge and low carbon competence are positively correlated with a sig value. (2-tailed) 0.214<0.05. Indicated that if students' knowledge increases, students' low carbon competence will also increase. This is supported by research conducted by Baartman & De Bruijn, (2011); Edelsbrunner et al. (2023) Knowledge and competence construct each other because several components of competence require good knowledge to produce good competence. Research conducted by Warastuti et al., (2025) Also shows direct empirical evidence that knowledge of renewable energy and low carbon education affirms students' low carbon competence, while Anwar & Bayani, (2024) Showed that implemented E-PjBL boosted environmental literacy and competency. and competency.

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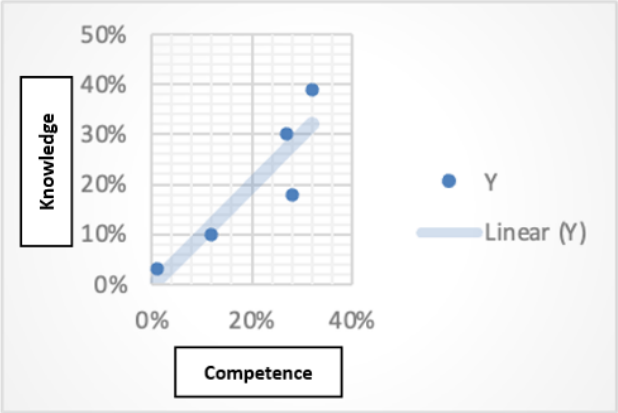

Figure 4. Correlation Between Knowledge and Competence of Low Carbon

Furthermore, this research also analyzed the geographical conditions using the analysis format from the climate change guidebook published by the Ministry of Education and Research. (BNSP et al., 2024).

Table 1. Analysis of Climate Change in Risks and impacts of change

The type of modality	The Shape of Implementation	How To Optimize
Human Capital	- Learners' understanding of the climate crisis and low carbon issues - Habitual low carbon behavior: waste management	- Strengthening understanding of climate crisis issues through low carbon education - Reinforcement of low carbon and climate-resilient behaviors in the form of habituation or programs in education units
Religious and Cultural Capital	Education unit culture related to morals to nature	Reinforcement through environmentally friendly attitudes
Social Media Capital	*Campaign* on learners' social media about low carbon lifestyle (4Rs)	Take climate action by changing personal habits and socializing with peers and social media

Climate change risk analysis and the impact of change consist of human capital, religious and cultural capital, and social media capital. According to research conducted by Sezgin et al., (2024) Human capital aspects in dealing with climate change support the reduction of carbon emissions through investment in education, training and increasing public awareness to protect the environment. The human capital aspect of the observation results is strengthened through climate education through knowledge and environmental change to optimize the understanding of low carbon and the impact of the climate crisis, as well as strengthening defenses against the climate crisis with a change in behavior on the environment. The aspects of religious capital and school culture show that there is already good progress in understanding the morals of maintaining environmental cleanliness (Kebersihan sebagian dari iman), so that from this understanding, schools with their policy only need to optimize again in the context low carbon education, this aspect is a foundation to rise climate resilient. (Raissa et al., 2021). Students' potential for pro-environmental behavior is shaped through social media. The social media aspect becomes a medium to take environmental conservation actions from students with the 4R campaign (Ballestar et al., 2020).

Table 2. Modality Analysis for Climate Change

Geographical Location of Education Unit	Things to watch out for	Selected Response
Located in a Rural Environment that is building infrastructure (Housing)	Higher air temperature increases	Educating healthy habits (Bringing water from home)
	Waste disposal management must be further improved to be more environmentally friendly	- Implementation the principle of 4*R (Reduce, Reuse, Recycle, Replace)* - Campaigning for environmentally friendly and sustainable lifestyles

From Table 2, teaching materials are developed by the geographical conditions, with the geographical conditons and modalities of educators and the potential of schools to respond to climate change. It shows that low carbon education teaching materials can be a potentially effective learning alternative to be developed. The Increase in temperature due to global warming has been felt by every individual in schools with the geographical conditions close to housing developments. This is the impact of cutting down plants. Then another problem found is the management of school waste management that has not been maximized. These problem can be sensed directly by students and become materials for analysis for students learning in low carbon education, until it results in a solution that students formulate as environmental learning, it is called contextual learning (Sumintono, 2018). Contextual learning is meaningful learning or situation-based learning that really happens around students. Students build knowledge throuh situations that occur around them, this learning reflects students' experiences and builds collaboration because together they analyze and construct knowledge into experiences (Dwinaeni et al., 2024). From the observation of georaphy conditions related to two things that are the focus of contextual learning, namely increasing temperature, and school waste management, the response chosen as a learning objective for students is the education of healthy living habits, like bringing water bottles from home, and the implementation of 4Rs. Carbon Neutral School Foundation (2022) emphasizes that the use of water bottles brought from home or tumblers instead of single-use plastic can not only reduce carbon emissions but also improve students' hydration, which has a positive impact on students' concentration.

The environmental care attitude of students has emerged well, with a high presentation of 50% of students out of 100 students having raised their environmental care attitude and expressed a positive response to agree, and 20% of students showed a tendency to strongly agree with the statement of environmental care attitude items. The more diverse the response categories, the freer the learners are to show their tendency of attitude responses (Hadi, 2013). However the results of the preference for environmental care attitude are different from those stated based on direct observation at school, there are still many students who do not behave like the tendency of the answers given in the questionnaire, therefore to optimize this, it can be improved again through a new approach, namely learning throuh low carbon education teaching materials that can increase the consistency of the sustainability of students' environmental care attitudes that can increase the consistency of the sustainability of students' environmental care attitudes.

Based on the desription above, low carbon education teaching materials need to be developed by containing many examples of low carbon living practice guidelines and encouraging students to practice them through independent or group tasks so that knowledge becomes the basis for students in protecting their environment because knoledge is a combination of information, experience and opinions formed betweeh individuals and their interacting environment (Chua, 2002; Mi & Nie,

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2012). The student has low carbon competence, namely the ability to know, formulate, and determine something (Marques-Valderrama et al., 2023). It is important, because in the questionnaire statement item 18 with the statement "I am able to take the role of expressing opinions about solutions to environmental problems around me" there is still a high percentage of students who answer neutral as much as 33%, disagree 7% and strongly disagree 11% with a total of 51% tendency to negative response disagree and strongly disagree. This implies that students still lack confidence based on strong knowledge. In line with this, Hasanuddin, (2020) states that opinions need to be equipped with knowledge as an initial construction for their new experiences. Learners who have qualified knowledge and competence will increase their confidence and be able to express opinions about solutions to environmental problems (Valero Haro et al., 2022).

The results of the study illustrate that quantitatively, the average individual absorption of learners on low carbon knowledge is still low, while only 28% have completed mastering low carbon competencies. This is consistent with the statement of learners who admit that there is still a lack of understanding of the concept of a low carbon footprint and concrete actions that are environmentally friendly. The correlation test shows a significant positive relationship between increasing knowledge will have a direct impact on the ability to apply the concept of low carbon.

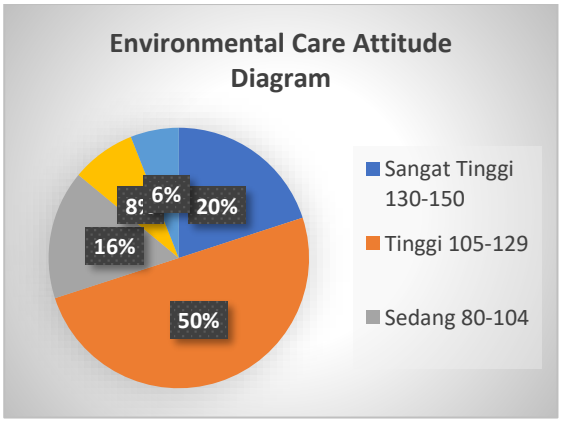

Figure 5. Environmental Care Attitude Diagram

Although 70% of students expressed environmental awareness through the survey results, field observations revealed that there are still inconsistent behaviors such as littering, and not bringing their own drinking and eating places, causing the use of plastic to remain high. The geographical condition of schools in rural areas, with the risk of flooding and the challenges of poor waste management, is also a concern, so that in learning activities, students must be presented with materials that are contextual to local conditions. (Salo et al., 2019). In several studies related to environmental care attitudes, several factors influence students' environmental care attitudes, including environmental knowledge factors, personal values and norms, empathy that raises motivationtion, awareness of protecting the environment, good habits in protecting the environment, self-efficacy and cognition that have a major effect on the transition of values to action. (Hasyim & Ningrum, 2024; Herlina et al., 2025; Kukkonen et al., 2018).

The school modalities observed have human resources, such as teachers and students who have an interest in environmental conservation. Then, the value of environmentally friendly culture around the school, such as 4R (Reduce, Reuse, Recycle, Replace), can also be used as inspiration for students to develop environmental care attitudes. The application of the 4R priciples in waste management has good potential in increasing students' knowledge, competence and environmental care attitudes, the function of applying the 4R principles is to make students actively participate in spreading the 4R culture and intervening in actions so that they can reconstruct bad habits that have an impact on the environment (Emilia et al., 2023; Helmi et al., 2018). The findings recommend the development of teaching materials that contain video so that they can increase students' low carbon knowledge (Christodoulou et al., 2024), Insert a carbon footprint calculation simulation in the teaching material so that students can understand the concept and improve their low carbon competency (Salo et al., 2019). Previous research shows that when schools implement environmental education learning that integrates carbon footprint calculation, it will increase students' awareness of environmental conservation, such as saving

electrical energy, water, and reducing single-use plastics. If this is done continuously over a long period, is is the same as supporting sustainability programs, especially in SDG 13: climate action (Pangestuaji Widodo et al., 2023). Local case studies and group reflections also help learners to strengthen the consistency of environmental care attitudes, so it is expected that teaching materials can increase the effectiveness of low carbon learning (Sagala et al., 2019). In environmental education, the preparation of appropriate teaching materials directs understanding of concepts in a structured manner to help students learn according to the cognitive lebel of students, materials that are in accordance with reality have an impact on everyday life and activate students' empathy and concern, for example learning about waste management because seeing firsthand the surrounding phenomena will be more meaningful than being presented with abstract examples and far from the reach of students. The right teaching materials also form a sustainable mindset so that it becomes a transformation tool not just materials or theory in line with research conducted by Kahar (2018) that local potential-based teaching materials increase students' environmental care attitudes throuh a character integration process that supports the internalization of the values of responsibility and love for the environment so that the material or theory learned is more meaningful because it inspires real action from students throuh the learning process.

CONCLUSION

This study shows that the knowledge and low carbon competence of seventh-grade students in Bogor Regency is still low, with a 57% absorption rate, while the absorption rate is said to be maximum if it has reached 60%. The attitude of environmental care is classified as good in the questionnaire, but the observation results show that not all statements are in line with the reflection of real behavior at school. Analysis of climate resilience and geographical conditions shows the need for contextualized learning and raising local issues. The 4R Culture is also a good asset to develop, and social media can be used as a medium to campaign for environmental awareness. Therefore, low carbon education teaching materials need to be developed by containing videos or pictures of local environmental issues, as well as collaborative assignments, in order to increase knowledge, competence, and consistency of students' environmental care attitudes.

REFERENCES

Adri, D., Sari, E. R., Wotu, A. H. J., Korenspondesnsi, *, & Kunci, K. (2024). *Education and Learning Journal Penggunaan Microsoft Excel dalam Penyusunan Data dalam Tabel Distribusi Frekuensi*. *5*(2), 94–111. http://dx.doi.org/10.33096/eljour.v5i2.1052http://jurnal.fai@umi.ac.id

Anwar, Z., & Bayani, F. (2024). *Fostering Student Competence in Data Interpretation and Environmental Literacy Through E-PjBL Model Assisted by Computational Simulation*. *10*(11), 8300–8310. https://doi.org/10.29303/jppipa.v10i11.9159

Apriyani, N. M., Soleh, D. A., & Sumantri, M. S. (2021). Tingkat Kepedulian Sosial Siswa Sekolah Dasar Pendahuluan Pendidikan dianggap sebagai wadah paling efektif dalam dan menumbuhkan dalam maupun baik berupa wawasan Sejalan terus menerus dikembangkan agar dari proses pelaksanannya tercipta generasi yang diha. *Pendidikan Dasar Perkhasa*, *7*(2), hal 110-117.

Asrial, A., Syahrial, S., Maison, M., Kurniawan, D. A., & Putri, E. (2021). Fostering Students' Environmental Care Characters Through Local Wisdom-Based Teaching Materials. *JPI (Jurnal Pendidikan Indonesia)*, *10*(1), 152. https://doi.org/10.23887/jpi-undiksha.v10i1.27744

Baartman, L. K. J., & De Bruijn, E. (2011). Integrating knowledge, skills and attitudes: Conceptualising learning processes towards vocational competence. *Educational Research Review*, *6*(2), 125–134. https://doi.org/10.1016/j.edurev.2011.03.001

Ballestar, M. T., Cuerdo-Mir, M., & Freire-Rubio, M. T. (2020). The concept of sustainability on social media: A social listening approach. *Sustainability (Switzerland)*, *12*(5), 1–19. https://doi.org/10.3390/su12052122

BNSP, KEMENDIKBUD, & RISTEK. (2024).

 | p-ISSN 1979-7281 | e-ISSN 2443-1281

Panduan Implementasi untuk Satuan Pendidikan.

Christodoulou, V., Bächtold, M., & Iordanou, K. (2024). Can a values and video-based activity increase knowledge or pro-environmental attitudes and behaviour? *E3S Web of Conferences*, *585*. https://doi.org/10.1051/e3sconf/202458510001

Chua, A. (2002). The influence of social interaction on knowledge creation. *Journal of Intellectual Capital*, *3*(4), 375–392. https://doi.org/10.1108/14691930210448297

Dwinaeni, E., Purwanto, A., & Eskundari, R. D. (2024). *Improving Natural Science Learning Outcomes on the Topic of the Human Excretory System through Contextual Learning of Modeling Techniques for Grade VIII Students of SMP*. *5*(2), 60–70. https://doi.org/10.32585/jbl.v5i2.5729

Edelsbrunner, P. A., Malone, S., Hofer, S. I., Küchemann, S., Kuhn, J., Schmid, R., Altmeyer, K., Brünken, R., & Lichtenberger, A. (2023). The relation of representational competence and conceptual knowledge in female and male undergraduates. *International Journal of STEM Education*, *10*(1). https://doi.org/10.1186/s40594-023-00435-6

Emilia, I., Eddy, S., Setiawan, A. A., Saputra, W., Jumingin, J., Septinar, W., Putri, Y. P., & Anggraini, P. (2023). Kemas Journal : Jurnal Pengabdian Masyarakat. *Kemas Journal: Jurnal Pengabdian Masyarakat*, *1*(1), 18–26.

Evriana, V., Alibasyah, L. M. P., & Tureni, D. (2016). Meningkatkan Hasil Belajar Siswa Pada Pokok Bahasan Tempat Hidup Tumbuhan Melalui Media Konkrit di Kelas 2 SDK Terpencil Punsu. *Jurnal Kreatif Tadulako, Universitas Tadulako*, *4*(7), 187–199.

Carbon Neutral Foundation (2022). *Building Low Carbon Habits in Schools: Practical actions for Students and Teachers.* https://www.carbonneutralschool.org/resources/low-carbon-habits-2022.pdf

Guilford, J. P. (1956). *Fundamental Statistics in Psychology and Education*. Mc Graw-Hill Book Co. Inc.

Hadi, S. M. (2013). The Comparison of Number Response Categories Towards Reliability of Mathematics Disposition Instrument. *Jurnal Evaluasi Pendidikan*, *4*(2), 105–117.

Handoyo, B., & Sukamto, H. (2019). Developing a Model of Geography Instructional Materials Based on the Spatial-Ecological Perspectives. *IOP Conference Series: Earth and Environmental Science*, *338*(1). https://doi.org/10.1088/1755-1315/338/1/012043

Haryani, E., Ahmad, S., & Aradea, R. (2021). Analisis Faktor-Faktor Penyebab Rendahnya Daya Serap Siswa pada Pelajaran Akuntansi. *Journal of Education Research*, *2*(2), 82–88. https://doi.org/10.37985/jer.v2i2.51

Hasanuddin, M. I. (2020). Pengetahuan Awal (Prior Knowledge) : Konsep dan Implikasi Dalam Pembelajaran. *EDISI : Jurnal Edukasi Dan Sains*, *2*(2), 217–232. https://ejournal.stitpn.ac.id/index.php/edisi

Hasyim, T., & Ningrum, M. S. (2024). Pengaruh Materi Pelestarian Lingkungan dalam Pelajaran Geografi dan Pola Hidup Masyarakat Setempat terhadap Sikap Peduli Lingkungan di Kalangan Siswa Sekolah Indonesia Kuala Lumpur. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *7*(4), 3884–3889. https://doi.org/10.54371/jiip.v7i4.4267

Helmi, H., Nengsih, Y. K., & Suganda, V. A. (2018). Peningkatan kepedulian lingkungan melalui pembinaan penerapan sistem 3R (reduce, reuse, recycle). *JPPM (Jurnal Pendidikan Dan Pemberdayaan Masyarakat)*, *5*(1), 1–8. https://doi.org/10.21831/jppm.v5i1.16861

Herlina, M., Istiawati, N. F., & Lailiya, I. (2025). *Analisis Korelasi Pengetahuan Lingkungan Terhadap Sikap Peduli Lingkungan Correlation Analysis of Environmental Knowledge to Environmental Concern Attitude*. *5*(1), 954–960.

PBB Indonesia. (2022). *Pendidikan perubahan iklim: Menjawab tantangan krisis iklim melalui pembelajaran. United Nations Indonesia.* https://indonesia.un.org/

Jabnabillah, F., & Margina, N. (2022). Analisis Korelasi Pearson Dalam Menentukan Hubungan Antara Motivasi Belajar Dengan Kemandirian Belajar Pada Pembelajaran Daring. *Jurnal Sintak*, *1*(1), 14–18.

Kahar, A. P. (2018). Application of Mangrove Ecosystem Material Based on Local Potential

to Improve Students' Environmental Awareness Attitude. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, *2*(1), 1–8.

Khumaedi, M. (2012). Reliabilitas Instrumen Penelitian Pendidikan (The Reliability of Education Research Instruments). In *Jurnal Pendidikan Teknik Mesin* (Vol. 12, Issue 1, p. 26). http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf

Kukkonen, J., Kärkkäinen, S., & Keinonen, T. (2018). Examining the relationships between factors influencing environmental behaviour among university students. *Sustainability (Switzerland)*, *10*(11). https://doi.org/10.3390/su10114294

Latif, I. A., Riyadi, R., & Saputro, D. R. S. (2019). The mathematics teachers' understanding of learning process based on 2013 curriculum 2017 revision. *Journal of Education and Learning (EduLearn)*, *13*(1), 140–146. https://doi.org/10.11591/edulearn.v13i1.9201

Mahfud, A., & Setya Budi, E. (20 C.E.). *Evolution of the Kurikulum Merdeka: Evaluation and recommendations for the future curriculum*. *22*(2), 250–261.

Marques-Valderrama, I., Chacartegui, R., Becerra, J. A., Pérez, Y. L., Jiménez, A. J. S., López Almeida, S. M., & López, C. D. (2023). A tool for the development of competencies in sustainability and carbon footprint reduction in schools. *36th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, ECOS 2023*, 3035–3046. https://doi.org/10.52202/069564-0272

Mi, L., & Nie, R. (2012). An Empirical Research on the Effect of Low-Carbon Knowledge of the Urban Residents on their LowCorbonized Energy Consumption Behavior. *Asian Journal of Business Research*, *2*(1). https://doi.org/10.14707/ajbr.120003

Pangestuaji Widodo, A., Putra Pamungkas, P., & Akbar Gozali, A. (2023). Recarbon: Aplikasi Edukasi Jejak Karbon Berbasis Flutter. *E-Proceeding of Applied Science*, *9*(1), 391–402.

Raissa, G., Sihotang, S., Christy, F., & Wijaya, K. (2021). Identification of cultural capital and sustainable behavior towards sustainable development. *IOP Conference Series: Earth and Environmental Science*, *764*(1), 1–8. https://doi.org/10.1088/1755-1315/764/1/012015

Sagala, R., Nuangchalerm, P., Saregar, A., & El Islami, R. A. Z. (2019). Environment-friendly education as a solution to against global warming: A case study at Sekolah Alam Lampung, Indonesia. *Journal for the Education of Gifted Young Scientists*, *7*(2), 85–97. https://doi.org/10.17478/jegys.565454

Salo, M., Mattinen-Yuryev, M. K., & Nissinen, A. (2019). Opportunities and limitations of carbon footprint calculators to steer sustainable household consumption–Analysis of Nordic calculator features. *Journal of Cleaner Production*. https://www.sciencedirect.com/science/article/pii/S095965261833049X

Santika, G. N., Suastra, I. W., & Arnyana, I. B. P. (2023). Membentuk Karakter Peduli Lingkungan pada Siswa Sekolah Dasar Melalui Pembelajaran IPA dengan Melalui Audio Visual (Menonton Video). *Jurnal Pembelajaran Dan Matematika Sigma (Jpms)*, *9*(1), 82–88. https://doi.org/10.36987/jpms.v9i1.3771

SETDA, Kab. Bogor. (2024). Bumikan gerakan peduli budaya lingkungan hidup di sekolah, Pemkab Bogor lakukan verifikasi calon sekolah Adiwiyata. Dinas Lingkungan Hidup Kabupaten Bogor. *Bumikan Gerakan Peduli Budaya Lingkungan Hidup Di Sekolah, Pemkab Bogor Lakukan Verifikasi Calon Sekolah Adiwiyata. Dinas Lingkungan Hidup Kabupaten Bogor*. https://setda.bogorkab.go.id/berita/seputar-opd/bumikan-gerakan-peduli-budaya-lingkungan-hidup-di-sekolah-pemkab-bogor-lakukan-verifikasi-calon-sekolah-adiwiyata?

Sezgin, F. H., Bayar, Y., Sart, G., & Danilina, M. (2024). Impact of Renewable Energy, Business Climate, and Human Capital on CO2 Emissions: Empirical Evidence from BRICS Countries. *Energies*, *17*(15), 1–17. https://doi.org/10.3390/en17153625

Sumintono, B. (2018). *Jurnal pengajaran matematika dan ilmu pengetahuan alam, vol 23, no 2 (2018)*. *23*(2), 8997.

Tunas, K. O., & Pangkey, R. D. H. (2024).

Kurikulum Merdeka: Meningkatkan Kualitas Pembelajaran dengan Kebebasan dan Fleksibilitas. *Journal on Education*, *6*(4), 22031–22040. https://doi.org/10.31004/joe.v6i4.6324

Ummah, I., Khotimah, N., & Fitri, R. (2024). Competence of Ecce Teachers in Implementing the Independent Curriculum. *EDUKASIA: Jurnal Pendidikan Dan Pembelajaran*, *5*(1), 501–508. https://doi.org/10.62775/edukasia.v5i1.794

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2022). Argumentation Competence: Students' Argumentation Knowledge, Behavior and Attitude and their Relationships with Domain-Specific Knowledge Acquisition. *Journal of Constructivist Psychology*, *35*(1), 123–145. https://doi.org/10.1080/10720537.2020.1734995

Warastuti, R., Permana, I., & Suryani, A. (2025). *Journal of Innovative Science Education Enhancing Students ' Scientific Skills Through a Low-Carbon Education-Based Youth Research Training Program*. *14*(I), 36–53.

Yuan, H., Zhou, P., & Zhou, D. (2011). What is low-carbon development? A conceptual analysis. *Energy Procedia*, *5*, 1706–1712. https://doi.org/10.1016/j.egypro.2011.03.290